Forbes Lake Water Quality

A Report on Water Quality Monitoring Results for Water Year 2010

Prepared for the City of Kirkland
by the King County Lake Stewardship Program

March 31, 2010

King County

Overview

In May 2006, residents at Forbes Lake began monitoring water quality through participation in the King County Lake Stewardship Program (KCLSP). Volunteer monitoring efforts continued through 2010. Physical and chemical data collected through five years of monitoring suggest that this small lake in the city of Kirkland is moderate to high in primary productivity (mesotrophic-eutrophic), with fair water quality. Primary productivity refers the rate at which algae in the lake grow and reproduce. The terms oligotrophic, mesotrophic, and eutrophic refer respectively to low, medium, and high productivity of algae in a lake. See the section on Trophic state indicators for a discussion of these terms.

Although there is no public access boat ramp, there are several public parcels adjacent to the lake, and the opportunity exists for members of the public to access the lake at several points, as well as to launch small car-top boats. This presents a potential vector for the introduction of noxious weeds to the lake. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

Later in this report references will be made to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the ratio of nitrogen to phosphorus (N:P). The TSI values and N:P ratios were calculated from the data collected through the volunteer monitoring program. TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the predicted algal bio-volume, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes.

Further introduction and a discussion of the philosophy of the volunteer lake monitoring program and the parameters measured can be found on-line at:

http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/2006_Intro.pdf

The discussion in this report focuses on the 2010 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Or can be provided in the form of excel files upon request.

Physical Parameters

Lake Level

Excellent precipitation and water level records were compiled for the 2010 water year (Figure 1). Water levels rose quickly in response to heavy or prolonged rain events during the period, which suggests that precipitation falling in the watershed flows quickly as surface water into the lake, with limited infiltration. Because the area of the watershed is large relative to the size of the lake, surface water flow from the watershed is likely to affect lake levels more than direct precipitation to the surface of the lake. Precipitation and lake level data collected since May 2006 suggest the lake does not vary a great deal through the year. Throughout 2010 the lake level varied around a relatively constant base level with short-lived increases at various times, most of which can be related to rainfall events. The highest lake levels do not appear to persist longer than a week (Figure 1).

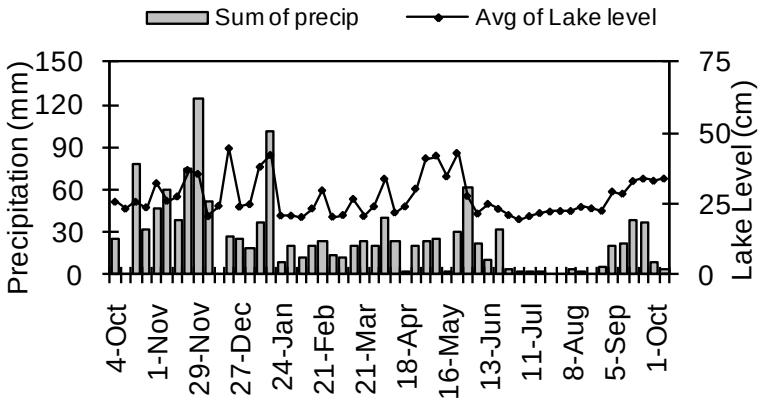

Figure 1. WY 2010 Forbes weekly Lake Level and Precipitation

Secchi Transparency

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered into the water from the surface.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analyses. Secchi transparency from May through October ranged between 1.5 and 2.5 meters (Figure 2). The summer average transparency was 1.9 m, which placed it in the lower range of water clarity for monitored small lakes in 2010.

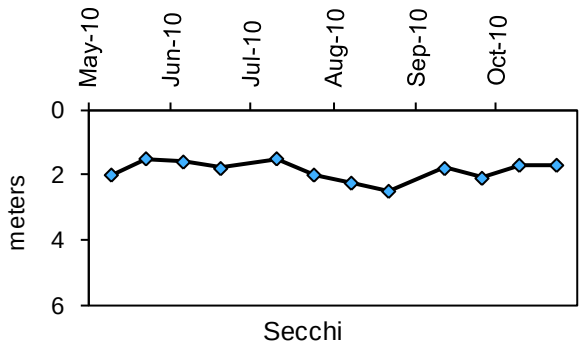

Figure 2. WY 2010 Forbes Secchi Levels

Temperature

Surface water temperatures ranged between 13.0 to 28.5 degrees Celsius, with an average of 18.9 degrees Celsius. The maximum temperature in late July coincided with the maxima at other lakes in the Puget Sound lowlands and was the highest value recorded among the monitored lakes for the sampling season (Figure 3).

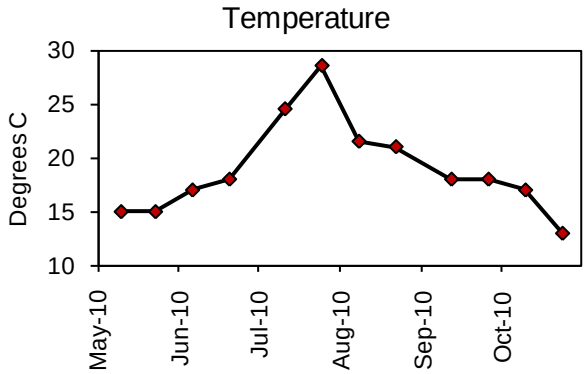

Figure 3. WY 2010 Forbes Temperature

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological primary productivity (from algae) is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential health and safety threat if blooms become dominated by species that can produce toxins.

Total Phosphorus and Total Nitrogen

Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth between May and October. During the monitoring period, the highest TN values were found in the second sample of the season, which then decreased through the summer and remained stable through September and October (Figure 4). TP followed a very similar pattern.

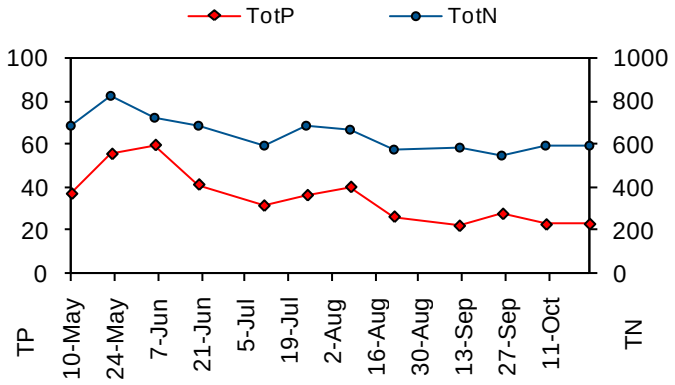

Figure 4. 2010 Forbes Lake Total Phosphorus and Total Nitrogen Concentrations

Ratio of Nitrogen to Phosphorus

The ratio of nitrogen to phosphorus (N:P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae). The presence of bluegreen algae can negatively impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air.Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, with the ratio of nitrogen to phosphorus (N:P) ranging from 12.2 to 26.4 with an average of 19.8. This suggests that, for much of the time during the sampling period, conditions were favorable for nuisance bluegreen growth. The lower N:P ratios occurred during spring and summer, but the ratio increased slightly in fall, suggesting conditions may have changed towards the end of summer.

Chlorophyll *a*

Chlorophyll *a* concentrations varied through the season (Figure 5). There was a broad maximum in mid June, followed by a larger one in mid-August, after which algal abundance appeared to decline (Figure 5). Pheophytin, which is degraded chlorophyll, was generally at low detection levels throughout the period.

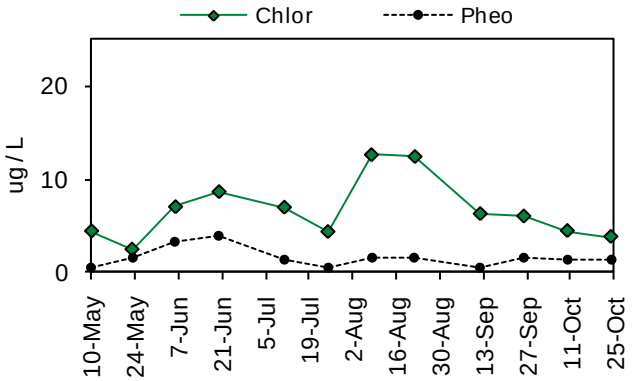

Figure 5. WY 2010 Forbes Chlorophyll *a* and Pheophytin concentrations

Profile Data

Profile data indicate that thermal stratification (temperature layering) was present in early summer and persisted at least through the second profile event in the late August profile event. Cool temperatures persisting in the deep water may indicate some influence of ground water. Higher concentrations of both total and dissolved phosphorus were found in the deep water in May as well as in August, suggesting that anoxia (lack of oxygen) could have triggered a release of phosphorus from the sediments. High ammonia concentrations in the deep water also indicate deep water anoxia (Table 1).

Table 1. Forbes Lake Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Forbes	5/23/10	1.5	1	15.0	2.4	1.5	0.821	0.066	0.0552	0.0096	0.389	56.6
			4	11.0	1.4	<MDL	0.750		0.0386			
			7	7.0	5.2	5.2	1.380	1.030	0.2420	0.2090		
Forbes	8/22/10	2.5	1	21.0	12.5	1.6	0.577	<MDL	0.0263	0.0028	0.381	60.0
			4	11.0	3.2	1.8	0.394		0.0169			
			7	7.0	26.7	12.1	2.010	1.700	0.4350	0.0188		

NOTE: In Table 1, <MDL stands for "below minimum detection level" of the analytical method.

The moderate values for UV254 indicate that the water of the lake is colored from organic substances, while the total alkalinity values show that the water in the lake is less soft than in less developed watersheds and is somewhat buffered against pH change.

Chlorophyll *a* profile data indicate that algae are present throughout the water column, but were distributed unevenly in August, with higher concentrations at the surface and near the bottom. The highest concentration of algae occurred in the seven meter sample in the August profile, which suggests that at that time there was a reservoir of algae in the deep water, where nutrients were plentiful.

Trophic State Index Ratings

A common method of tracking water quality trends in lakes is by calculating values for the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological productivity of the lake. The TSI is based on water clarity (Secchi), concentrations of total phosphorus (TP), and chlorophyll *a*. The Index relates to 3 categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

The 2010 TSI value for TP was well above the eutrophic threshold, while the TSI value based on Secchi transparency (water clarity) was slightly lower, and the TSI indicator for Chlorophyll *a* was in the upper end of the mesotrophic range (Figure 6). The average of all 3 TSI indicators in 2010 put Forbes Lake into the lower eutrophic range for the year, slightly above the averages for 2006 through 2009. Additional years of monitoring would be necessary to determine if the trophic status of Forbes Lake is relatively stable or potentially following an upward trend in algal productivity.

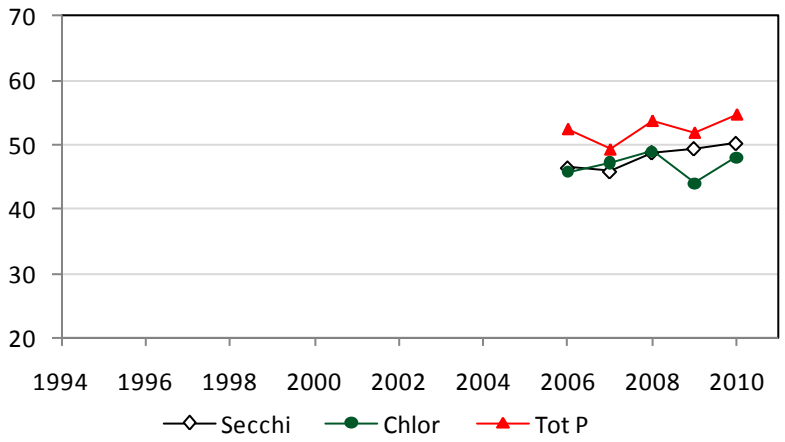

Figure 6. Forbes Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Forbes Lake has been more or less stable over the period measured, but may be showing signs of an increasing trend over time. Low average N:P ratios could indicate conditions are favorable for nuisance bluegreen algae blooms, particularly in the spring and summer. However, not enough data has been collected yet to verify trends statistically.

Monitoring of nutrient and chlorophyll concentrations should be continued to see if an increasing trend can be verified. Close monitoring of algae blooms at the lake should also be done, including participation in the Washington State Department of Ecology's Toxic Algae Monitoring program to determine whether or not blooms found in the lake may occasionally produce toxins.